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Confabulation: what is associated with its rise and fall? A study in brain injury.

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ABSTRACT

The aim of this study was to investigate cognitive and emotional factors associated with the presence and clinical course of confabulation.

24 confabulating participants were compared with 11 brain injured and 6 healthy controls on measures of temporal context confusions, mood state (elation, depression) and lack of insight. Measures of autobiographical memory and executive function were also available. Changes in confabulation and these other measures were monitored over 9 months in the confabulating group.

We found that temporal context confusions were more common in confabulating patients than in healthy controls, and that the decline in these errors paralleled the recovery from confabulation. However, temporal context confusions were not specific to the presence of confabulation in brain injury; and their decline was not correlated with change in confabulation scores over 9 months. We found that elated mood and lack of insight discriminated between confabulating and non-confabulating patients, but these measures did not correlate with either the severity of confabulation or change in confabulation scores through time. What seems to have been most strongly associated with the severity of confabulation scores at 'baseline' and changes through time (over 9 months) were the severity of memory impairment (especially on autobiographical memory) and errors on executive tests (particularly in making cognitive estimates). Greater autobiographical memory and executive impairment were associated with more severe confabulation.

The findings were consistent with the view that confabulation results from executive dysfunction where autobiographical memory is also impaired; and that it resolves as these impairments subside.

Keywords: confabulation, brain injury, memory, mood, cognition

Confabulations are false or erroneous memories arising involuntarily in the context of a neurological amnesia. Their content may be entirely or substantially erroneous, or they may consist of real memories jumbled up and retrieved out of context (Kopelman, 2010). Confabulated memories are usually autobiographical; they arise unintentionally; and the patient is usually unaware of his/her condition (Burgess & Shallice, 1996). Confabulations often compel the person to act upon them (Schnider, 2001). Confabulation is a very debilitating condition: the person may self-discharge from hospital against medical advice, and social support networks are often strained. Relatives may suffer unjustified paranoid accusations, and/or struggle to appreciate the unintentional nature of the confabulations (Baddeley & Wilson, 1986). Several theoretical models have attempted to explain the underlying cognitive deficits which give rise to confabulation. However, to date there is no consensus regarding the definition, classification, or causes of this clinical condition, how it arises, and its clinical course.

Spontaneous confabulation has been defined as “a persistent, unprovoked outpouring of erroneous memories” (Kopelman, 1987, 1999, 2010), whereas momentary or provoked confabulations consist of fleeting intrusion errors or distortions when memory is challenged or tested. However, this distinction has been challenged. On the one hand, Schnider and colleagues (Schnider, von Daniken, & Gutbrod, 1996; Schnider, 2003, 2008) have argued that ‘spontaneous confabulation’ should be reserved for patients who act upon their false memories; and they have

² List of abbreviations used in the text (in alphabetical order): AMI: Autobiographical Memory Interview; ACoA: Anterior Communicating Artery Aneurysm; CET: Cognitive Estimation Test; DK: Don’t Know; IQ: Intelligence Quotient; MREC: Multicentre Research Ethics Committee (UK); MTL: Medial Temporal Lobe; NART-R: National Adult Reading Test – Revised; PTA: Post Traumatic Amnesia; ROC: Receiver Operating Characteristics; SCOLP: Speed and Capacity of Language Processing; T1: baseline assessment (Time 1); T3: 9-month follow up (Time 3); TMT: Trail Making Test; WAIS-III: Wechsler Intelligence Scale – III; WMS-III: Wechsler Memory Scale – III; TCC: Temporal Context Confusion; WASI: Wechsler Abbreviated Scale of Intelligence

argued for other varieties of confabulation. On the other hand, Gilboa and Moscovitch (2002); (Gilboa et al., 2006); McVittie (McVittie, McKinlay, Della Sala, & MacPherson, 2014) have argued that there is overlap between these categories of confabulation or, at least, not a clear boundary between them (very florid confabulations can be, at least partially, ‘provoked’). Nevertheless, there appears to be considerable agreement that spontaneous confabulation arises when executive dysfunction and frontal lobe damage are superimposed upon an amnesic deficit (Luria, 1976; Stuss, Alexander, Lieberman, & Levine, 1978); Kapur & Coughlan, 1980; Baddeley & Wilson, 1986). Moreover, more recent neuroimaging and evoked potential investigations have particularly pinpointed damage within the ventro-medial and/or orbito-frontal brain regions (Schnider, 2003; Gilboa et al., 2006; Toosy et al., 2008; Turner, Cipolotti, Yousry, & Shallice, 2008; Gilboa & Verfaellie, 2010; Nahum, Bouzerda-Wahlen, Guggisberg, Ptak, & Schnider, 2012; Hebscher, Barkan-Abramski, Goldsmith, Aharon-Peretz, & Gilboa, 2015; Schnider et al., 2013; Manuel, David, Bikson, & Schnider, 2014).

There are various theories of confabulation, which have been reviewed elsewhere (Kopelman, 1999, 2010; Schnider, 2008; DeLuca, 2009; Fotopoulou, 2010). These include: (i) theories of context memory confusion or a deficit in ‘reality monitoring’ (Schnider, 2003, 2008); (ii) the theory that temporal consciousness is intact, but malfunctioning (Dalla Barba, 1993; Dalla Barba, Cappelletti, Signorini, & Denes, 1997; La Corte, Serra, Attali, Boisse, & Dalla Barba, 2010); (iii) theories which emphasise deficits in strategic retrieval, trace specification, and verification/editing processes (Burgess & Shallice, 1996; Schacter, Norman, & Koutstaal, 1998; Gilboa et al., 2006); and (iv) motivational accounts of confabulation (Conway & Tacchi, 1996; Fotopoulou, Conway, Griffiths, Birchall, & Tyrer, 2007; Fotopoulou, Conway, Solms, Tyrer, & Kopelman, 2008). Finally, (v) interactionist/multifactorial accounts combine elements of several of these theories (Johnson, O'Connor, & Cantor, 1997; Kopelman, Ng, & Van Den Brouke, 1997).

Of particular relevance to this study is Schnider's account because it has attempted to explain not only the cause of behaviourally spontaneous confabulations, but also their clinical course (Schnider, Ptak, von Daniken, & Remonda, 2000; Schnider, 2008; Nahum, Ptak, Leemann, Lalive, & Schnider, 2010). In a series of elegant experiments, Schnider and colleagues compared spontaneous confabulators to non-confabulating amnesic patients (Schnider et al., 1996, 2000; Schnider & Ptak, 1999). They found only one feature distinguished between the two groups - performance on a continuous recognition task at a second 'run', where 8 previous targets had become distractors and 8 distractors now became targets presented 6 times, a potentially very useful diagnostic task. The authors inferred that the key cognitive deficit giving rise to confabulation was temporal context confusion (TCC). In an important study, Schnider et al. (2000) found that performance on the TCC task improved as patients recovered from confabulation, whereas other cognitive measures did not change in parallel with recovery from confabulation. Subsequently, Schnider (2003, 2008) reinterpreted TCC as reflecting a defective 'filtering' mechanism with respect to incoming information or 'ongoing reality'. More specifically, they postulated a deficit in suppressing memories that no longer corresponded to the present. Schnider (2008) explained that this was why confabulators appear to 'live in the past', and are so convinced of their false memories that they act upon them. Schnider (2008) distinguished between four types of confabulation: intrusions (provoked confabulations), momentary, fantastic, and behaviourally spontaneous confabulations. Nahum et al. (2012) and Bouzerda-Wahlen, Nahum, Ptak, & Schnider (2013) have argued that, while momentary confabulations are associated with a number of cognitive impairments, including executive deficits, behaviourally spontaneous confabulation and disorientation are associated with deficient reality monitoring, an inability to learn that one stimulus no longer predicts the occurrence of another. This was attributed to a defective orbito-frontal filtering mechanism.

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Gilboa et al. (2006) used the TCC to explore these findings. They compared a group of confabulating patients who had suffered anterior communicating artery aneurysm (ACoA), non-confabulating patients with similar underlying pathology, amnesic patients with medial temporal lobe (MTL) lesions, and healthy controls. Consistent with Schnider et al.'s (1996, 2000) results, confabulating patients' performance on the TCC task was worse than that of healthy controls and amnesic (MTL) patients. However, the task did not discriminate between confabulating and non-confabulating patients with anterior communicating artery aneurysm (ACoA) and those without. The non-confabulating ACoA group overlapped with both the confabulating patients and the healthy controls. Moreover, Gilboa et al. (2006) obtained a similar pattern of results on a task in which participants were asked to make difficult, visuo-perceptual discriminations, instead of temporal context judgements. Gilboa et al. (2006) concluded that, whilst TCC errors might be sensitive to confabulation, they were not specific to this condition. However, it should be noted that there were only five confabulators in the original Schnider et al. (1996) investigation, and only four confabulators in Gilboa et al.'s (2006) study.

Other theorists have attributed spontaneous confabulation to problems in trace specification or verification at retrieval (Kopelman, 1999, 2010). For example, Burgess and Shallice (1996) stated that there were deficits either in 'strategic control', or trace specification, or the editing out of errors, and Moscovitch and Melo (1997) and Schacter et al. (1998) employed different terminology to argue very similarly. Gilboa et al. (2006) placed emphasis upon impaired strategic retrieval and, in particular, defective pre-conscious, post-retrieval monitoring (Gilboa & Verfaellie, 2010; Hebscher et al., 2015). More recently, Ghosh, Moscovitch, Colella, & Gilboa (2014) have argued that patients with ventro-medial prefrontal cortical lesions have difficulty instantiating task-relevant schemas, and, instead, rely on inappropriately activated memory schemas (Ghosh & Gilboa, 2014) even in non-memory tasks. These authors demonstrated

impaired reaction times by confabulating patients in processing schema and in rejecting inappropriate schema, even though their reaction time on other tasks was not impaired.

By contrast, the motivational account of confabulation has focussed upon cognitive factors and the influence of mood and emotion (Fotopoulou, Solms, & Turnbull, 2004; Turnbull, Jenkins, & Rowley, 2004; Fotopoulou, 2008; Metcalf, Langdon, & Coltheart, 2010). Several authors have found that confabulations may promote the individual's self-perception in a favourable or idealised light (Fotopoulou, 2010; Turnbull, Berry, & Evans, 2004). In this way, confabulations might help the individual cope with a rather depressing reality (e.g. being in hospital, loss of job/status, etc). Furthermore, there is some indication that confabulations may be related to depressed mood, although more research is required (Fotopoulou et al., 2008; Metcalf et al., 2010). In a previous study (Bajo, Fleminger, & Kopelman, 2010), we found that the content of confabulations can be, but is not always, associated with strong emotion; and that this emotions may be either pleasant or unpleasant. One of the aims of the present study was to explore whether mood state (depression; elation) is associated with confabulation.

There is evidence from several studies of psychiatric patients that elated mood affects memory (Corwin, Peselow, Feenan, Rotrosen, & Fieve, 1990; Gainotti & Marra, 1994). Corwin et al. (1990) found that, during a recognition memory task, patients with elated mood (or 'hypomania') gave many more false positives than controls, demonstrating a liberal response bias. This subsided when their mood disorder was treated with beta-blockers, the patients then adopting a more conservative decision-making bias. There is also clinical evidence suggesting that confabulators may show mild elation and/or poor insight (Weinstein & Kahn, 1950). Lack of insight is also considered an integral characteristic of the syndrome of confabulation in some theoretical models of confabulation (e.g. Burgess & Shallice, 1996). Furthermore evidence suggests that recovery from confabulation may be accompanied by increased awareness of

amnesia and confabulation (Mercer, Wapner, Gardner, & Benson, 1977; Feinberg & Roane, 1997; DeLuca, 2000; Nahum et al., 2010). However, elated mood and insight have not been formally investigated in previous studies of confabulation. Consequently, in this study, we explored whether elated mood and/or limited insight were related to confabulation.

In summary, many authors have viewed confabulation as the consequence of cognitive deficits, such as in temporal context memory or reality monitoring, or alternatively strategic retrieval, trace specification, and/or editing/verification processes. In addition, there is evidence indicating that confabulations may also be modulated by motivational factors, including mood state and lack of insight. Elated mood in psychiatric patients leads to significant false recognition on memory tasks, but this improves when the underlying mood disorder is successfully treated.

In the present investigation, we studied a large group of confabulating patients, non-confabulating brain-injured patients, and healthy controls to attempt to resolve the following issues:

- 1) Are temporal context confusions (TCC) predictive of the presence of confabulation and its time course (the Schnider hypothesis?)
- 2) Are affective factors (mood state), or a lack of 'insight', predictive of confabulation and its time-course (as Corwin et al.'s 1991 findings suggested)?
- 3) Are memory and executive performance predictive of confabulation and its time-course (the 'traditional' notion)?

2.1. Participants

Written consent was obtained for all participants according to procedures approved by a Multicentre Research Ethics Committee (MREC). Three groups of participants were recruited: (i) 24 confabulating brain injured patients; (ii) 11 non-confabulating brain injured patients, and (iii) six healthy participants.

In order to be included in the study patients were required to have a primary diagnosis of acquired brain injury resulting from pathologies such as traumatic brain injury, hypoxia, subarachnoid haemorrhage, Wernicke-Korsakoff syndrome, cerebral infection and brain tumour, each diagnosed by the responsible clinician accordingly. The confabulating patients were selected on the basis of clinical evidence of spontaneous confabulation *and* a score of 8 or above on the 'episodic' component of Dalla Barba's (1993) Confabulation Battery (see below) (Kopelman et al., 1997). 20 out of 24 of the confabulators had acted upon their confabulations (e.g. a school teacher who patrolled the hospital corridors, believing he was inspecting the dormitories at a boarding school; another patient who travelled 30 miles to his home, believing he was still living there). Clinical neuroimaging (MRI, CT) was available for 21 of the patients: 10 showed ventro-medial prefrontal or orbito-frontal pathology, and eight showed atrophy encompassing these brain regions, whereas three showed no visible changes at these sites. Patients with *no* clinical diagnosis of confabulation and a score of 4 or less on the episodic section of the Confabulation Battery were included in the brain injured non-confabulating group.

2.1.1. Recruitment sites

Patients were recruited via consecutive referrals mainly from in-patient, but also from out-patient clinics of the following hospitals: Edgware Hospital Brain Injury Rehabilitation Unit (BIRU), South London and the Maudsley Trust (SLAM), Guy's and St Thomas' Trust hospitals, and Blackheath Brain Injury Rehabilitation Unit. Staff at these sites were asked to refer to us any patient they thought was confabulating. In order to recruit healthy controls, relatives or carers of brain injured individuals were approached at BIRU's outpatient clinic.

2.1.2. Ascertainment

2.1.2.1. Confabulating patients: A total of 46 confabulating patients were referred to us and assessed. Three of these refused to participate in the study. Two patients started the study but did not complete the follow-ups. One patient was excluded because severe confusion prevented meaningful conversation. Another patient was suffering a major mental health illness at the time of recruitment and was also excluded. Five patients were excluded because no informant was available to verify their confabulations. Another 10 patients were interviewed and excluded because they did not meet the criteria for evidence of confabulatory behaviour set above. This left 24 confabulating brain injured participants in the experimental group.

2.1.2.2. Non-confabulating patients: 23 non-confabulating brain injured controls were approached. Two of these refused to participate in this study. Another 2 did not complete the follow-ups. One patient was excluded because no informer was available to verify their memories. A further 7 patients were excluded because they did not meet the criteria for matching them to the experimental group. This left 11 non-confabulating brain injured patients in the control group; they were matched to confabulators for severity of memory disorder (using the WMS delayed memory subtest) and level of education (Schnider et al., 1996), (see table 1 for

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details); they were also matched for severity of cognitive deficits (according to MMSE scores) and age.

2.1.2.3. Healthy participants: 6 healthy participants were approached and recruited. They were matched to the experimental group on age and level of education.

2.2. Background assessments

The following background neuropsychological tests were carried out.

2.2.1. General reasoning tests:

- the revised National Adult Reading Test (NART-R) as a measure of premorbid IQ (Nelson & Willison, 1991); the Wechsler Abbreviated Scale of Intelligence (WASI) or the Wechsler Adult Scale of Intelligence – III (WAIS-III) as measures of current IQ (Wechsler, Wycherley, Benjamin, Crawford, & Mockler, 1997a); Wechsler, 1999);

2.2.2. Speed of processing:

- the Speed and Capacity of Language Processing (SCOLP) (A. D. Baddeley, Emslie, & Nimmo-Smith, 1992) and the WAIS-III ‘digit symbol’ subtest (Wechsler, et al., 1997a);

2.2.3. Executive function:

- the Trail Making Test (TMT) (Reitan, 1958), the Cognitive Estimates Test (CET) (Shallice & Evans, 1978), and the Hayling & Brixton Tests (Burgess & Shallice, 1997).

2.2.4. Memory:

- the Wechsler Memory Scale–III as a measure of anterograde memory (Wechsler, Wycherley, Benjamin, Crawford, & Mockler, 1997b). The childhood, adulthood and recent episodic events sections of the Autobiographical Memory Interview (Kopelman, Wilson, & Baddeley, 1990) was employed as a measure of retrograde personal memory.

2.3. Procedures

The experimental tasks were carried out on inclusion to the study. In the case of confabulating patients, this was at a mean of 6 months following their brain injury (Table 1). These tests were repeated 3 months later, and again 9 months after the initial assessment. The tasks were:

2.3.1. The Dalla Barba (1993) Confabulation Battery was adapted for the UK (Kopelman, et al., 1997). This interview asks questions about orientation in time and place, episodic memory, personal semantic memory, and items designed to provide a ‘Don’t Know’ response. Responses were recorded verbatim, and these were verified against information provided by relatives or held within medical records. Healthy participants were given only the general semantic and orientation sections of the Confabulation Battery, as it was not possible to verify their answers to the remaining questions.

2.3.2. Schnider et al.’s (1996) temporal context confusion (TCC) task. In the first ‘run’ of this task, participants were shown 120 (Snodgrass & Vanderwart, 1980) line drawings of objects and animals on a computer screen, eight drawings were repeated six times (targets), and 112 drawings were shown only once (distractors). Participants were asked to say whether they had

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seen a given slide before or not. After a 20-minute time-delay, a second 'run' was administered, in which previous targets became distractors, and eight distractors were now targets, shown six times. Participants were asked to say whether they had seen a given item in this 'run' or not. In order to calculate temporal context confusions (TCC), the following formula was used: $TCC = (FP2/H2) - (FP1/H1)$ (FP=false positives in run 1 or 2; H=hits in run 1 or 2 (Schnider et al., 1996, 2000).

2.3.3. Current mood state:

- The Altman Self-Rating Mania Scale (ASRM) –mania subscale for elated mood (Altman, Hedeker, Peterson, & Davis, 1997) and the Hospital Anxiety and Depression Scale for depressed mood (HADS) (Zigmond & Snaith, 1983) were used.

2.3.4. Insight:

- A semi-structured interview was constructed specifically for this study. It asked about why in hospital, any brain damage, memory and thinking, and general self-care. There were seven items, each score 0 to 2 with high scores indicating a lack of insight (see supplementary material Appendix 1).

2.4. Statistical analyses and experimental design

Differences between the three groups (confabulators, non-confabulating brain-injured, healthy controls) on background neuropsychological tests, mood, and cognitive measures were investigated using one way or two way ANOVAs or t-tests. Kruskal-Wallis, and Mann-Whitney U tests were used where parametric assumptions were not met. Chi-square was used to examine frequency distributions, with a Friedman correction for multiple comparisons as appropriate.

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With parametric tests, the Holm's Bonferroni correction for multiple comparisons was used (Walsh, 2004).

Correlational analyses (Pearson's r) were used to examine the associations between variables, and, in particular, the correlates between change scores over 9 months. A backward stepwise binary logistic regression was used as a first step for determining the ROC (receiver operating characteristics) curve in differentiating confabulating from non-confabulating brain injured patients. A forward stepwise multiple regression was used to determine the degree of variance attributable to particular variables.

3. RESULTS

Table 1 shows age, and level of education for the three groups. There were no significant differences between the groups in terms of gender, age, or education. Table 1 also shows the duration of Post Traumatic Amnesia (PTA) and time since injury. There was a trend for these to be longer in the non-confabulating group, but the two brain-injured groups did not differ significantly in this regard. It should be noted that the confabulation group was first assessed at a mean of 6 months (± 3.7) following their onset, meaning that their 9-month follow-up occurred at a mean of 15 months following the onset of their disorder.

TABLE 1 ABOUT HERE

Table 2 shows summary statistics for confabulating and non-confabulating patients on background cognitive reasoning and processing measures. NART-R and WASI mean scores indicated that Full Scale I.Q. had declined by approximately 13-14 points, relative to predicted premorbid (NART-R) scores, in both brain-injured groups at inclusion in the study. SCOLP and Digit Symbol scores indicated reduced speed of processing (below the 5th percentile). There were no significant differences between the two brain-injured groups on any of these measures. Table 2 also indicates that both brain-injured groups were severely and comparably impaired across a range of executive tests (Trail Making B, cognitive estimates, Hayling, Brixton). Likewise, both groups were severely but comparably impaired at standard verbal and visual, recall and recognition anterograde memory tasks. There were no significant differences between the two patient groups at any of these tasks.

Table 2 also shows mean accuracy scores of two brain-injured groups on the episodic schedule of the Autobiographical Memory Interview (AMI). Confabulating patients scored ‘borderline abnormal’ level for childhood and young adulthood memories, and ‘definitely abnormal’ for recent personal events. Non-confabulating brain-injured patients performed at the ‘acceptable’ level for childhood, but ‘borderline abnormal’ for young adult memories, and ‘definitely abnormal’ for recent autobiographical memories. The pattern of performance in both groups was consistent with a temporal (or ‘Ribot’) gradient, i.e. relative sparing of early memories. A repeated measures two-way ANOVA gave a significant main effect of group ($F_{2,32}=5.85$, $P=0.02$), indicating that the non-confabulating patients scored more highly than the confabulators. There was also a significant effect of time period: $F_{1.70,54.44}^3=7.00$, $P=0.04$). But there was no significant group by time-period interaction ($F_{1.70,54.44}^3=1.30$, $P=0.28$), indicating the slope of the ‘temporal gradient’ did not differ between the two patient groups. Planned pairwise

³ Mauchly’s test indicated that the assumption of sphericity had been violated ($\chi^2(2)=0.735$, $P=0.008$), therefore degrees of freedom were corrected. Since $\epsilon>0.75$, Huynh-Feldt estimates of sphericity were used to correct degrees of freedom on this occasion ($\epsilon=0.851$).

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comparisons showed that in both groups recall of recent events was significantly less accurate than recall of childhood memories (mean difference= 1.32, 0.05) and of adulthood events (mean difference=1.5, $P=0.01$), after Bonferroni correction for multiple comparisons. This indicated that in both groups events that happened during participants' early lives were better remembered than events within the five years prior to this assessment. No significant differences were found between recall of childhood and adulthood events (mean difference= 0.16, $P= 1.00$).

Table 2 approx. here

3.1. Findings at 'baseline'

Fig. 1 shows how individual confabulating and non-confabulating brain-injured patients as well as healthy controls performed on Schnider's TCC task at baseline in the current study. All the healthy controls scored below Schnider et al.'s (1996) cut-off of 0.28 on this task. 17 of the confabulating patients scored above this cut-off point, but seven scored below the cut-off. The non-confabulating brain injured patients overlapped with both the confabulators and the healthy controls, five scoring above and six below the cut-off.

One-way ANOVA results showed a near-significant difference in performance across the three groups of participants ($F_{2,38}=3.11$; $P=0.06$).

Fig. 1 approx here

Table 3 compares the performance of the confabulating and non-confabulating brain-injured groups on TCC and on our insight, elated mood, and depressed mood scales. There was no significant difference between these two groups, taken in isolation, on the TCC scale ($t_{1,33}=1.28$, $P=0.21$, two-tailed). They did differ on the insight scale, the confabulating group showing the lesser insight ($t_{1,32}=2.26$, $P=0.03$, two-tailed). They also differed significantly in terms of elated mood, the confabulating group showing the more elated mood ($t_{1,32}=2.05$, $P=0.04$, two-tailed). However, they did not differ significantly in terms of depressed mood ($t_{1,32}=0.02$, $P=0.99$, two-tailed).

Table 3 approx. here

A backward stepwise binary logistic regression, used to examine the concurrent associates of confabulation, showed that for each 1 unit reduction in insight scores (improvement in insight) there were 30% lower odds of confabulating ($P=0.03$); and for each 1 unit reduction in elated mood scores there were 33% lower odds of confabulating ($P=0.04$). Fig. 2 shows a ROC (Receiver Operating Characteristics) curve for a joint variable (insight, elated mood) calculated from this regression analysis (*fitted values* = $2.77 + [-0.36 \times \text{insight score}] + [-0.40 \times \text{elation score}]$). In differentiating confabulating from non-confabulating brain-injured patients, this ROC curve gave 78% sensitivity and 82% specificity.

Fig. 2 approx. here

Finally, Table 4 shows the correlates of the severity of confabulation (on the Dalla Barba battery) within the confabulating group. Correlations are shown for the total number of confabulations across the whole battery, and for the number of confabulations in the 'episodic memory' section only. It will be seen that there was a near-significant correlation between TCC score and total

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confabulations ($r=0.34$, $P=0.05$) but not between TCC and episodic confabulations. Significant correlations were obtained between the number of correlations and AMI episodic memory scores for early adult and recent life, Logical Memory immediate and delayed, and cognitive estimates and Hayling test error scores. A stepwise, forward regression, based on AMI 'recent' score, TCC scores, and AMI 'young adult' score accounted for 49% of the variance (R^2) in total confabulation scores.

Table 4 approx. here

3.2. Follow-up of confabulation

Recovery from confabulation was examined over a 9-month period, starting from 'baseline', which was actually 6 months after the onset of confabulation in this group (see Table 1 above).

Fig. 3A shows the findings for the confabulating group in terms of the mean number of confabulations expressed as a proportion of total statements on the Dalla Barba battery, and also as a proportion of statements on the episodic memory component of the battery. Both measures showed a steep decline over 9 months in terms of the proportion of confabulatory statements. Fig. 3A also shows the TCC curve from Schnider's test, superimposed upon the histograms, indicating that temporal context confusions appear to have declined in parallel. Fig. 3B shows changes in mood and insight (high scores = poor insight) over the same time-period. It will be seen that insight and elated mood improved, and depressed mood showed an inverted U-shaped curve. Repeated measures ANOVAs showed a significant linear effect of time on episodic confabulations ($F_{1,23}=88.78$, $P=0.00$), total confabulations across all sections of the Dalla Barba confabulation interview ($F_{1,22}= 85.59$, $P=0.00$), and on insight scores ($F_{1,21}=18.71$, $P=0.00$). Similar analyses carried out with the remaining experimental variables were not significant: TCC

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($F_{1.37,30.16}^3 = 2.10, P=0.14$), depression ($\chi^2_2=0.34, P=0.86$)⁴, or elation ($\chi^2_2= 2.70, P=0.26$)⁴. This indicated there was no significant change over time in terms of TCC, elated or depressed mood.

Fig. 3A and B approx here please

Next, we examined the correlates of decline in confabulation across individuals by examining the change in total confabulations on the Dalla Barba battery between baseline (T1) and 9 months (T3) against change scores (T1-T3) on our independent variables over the same time-period. We also examined these correlations for the 'episodic memory' section of the Dalla Barba battery, taken in isolation. Table 5A shows that none of the correlations between change in confabulations (T1-T3) and change in TCC score, elated mood, depressed mood, and insight score was statistically significant ($r=0.05$ to 0.26). As shown in Table 5B, it was change in memory scores and change in cognitive estimates error scores (T1-T3) which were statistically significant. A stepwise regression, based on change in AMI episodic young adult score and change in cognitive estimates error scores predicted 44% of the variance (R^2) of change in total confabulation scores over 9 months.

Table 5A & B approx here

4. DISCUSSION

4.1. Confabulating versus non-confabulating groups

⁴ The Friedman test for multiple comparisons was used.

³ Mauchly's test indicated that the assumption of sphericity had been violated ($\chi^2(2)=12.89, P=0.002$), therefore degrees of freedom were corrected. Greenhouse-Geisser estimates of sphericity were used to correct degrees of freedom on this occasion ($\epsilon=0.686$).

In this study, we compared the performance of confabulating versus non-confabulating brain-injured patients with healthy controls. Confabulation was determined on clinical grounds and by scores on the episodic component of Dalla Barba's battery. The clinical and Dalla Barba criteria were entirely consistent, and none of the patients had to be excluded because their Dalla Barba scores did not match their clinical diagnosis. This makes it very unlikely that the phenomenon was purely a consequence of the nature of the interview or discussion between the experimenter and the participant (compare McVittie, et al., 2014). Furthermore, 21 out of 24 of the confabulators had acted upon their confabulations, consistent with Schnider's (2003, 2008) more specific definition of 'spontaneous confabulation'.

Both groups of patients performed similarly on background neuropsychological tests with a decline in estimated current I.Q., relative to estimated premorbid scores, and impairments on tests of anterograde memory, executive function, and speed of processing.

On the Autobiographical Memory Interview (AMI), both groups performed significantly worse in terms of 'recent' personal memories, compared with childhood or young adult memories. There was also a main effect of group, indicating that the confabulating patients recalled autobiographical events less accurately than did the non-confabulating memory-disordered patients. Although there was not any significant group by time-period interaction, the findings are consistent with the suggestion that older autobiographical memories are more stable (Dalla Barba et al., 1997; Dalla Barba, 2009; Dalla Barba & Boisse, 2010).

4.2. Findings at baseline

4.2.1. The role of TCC in the onset of confabulation

Schnider and colleagues have claimed that TCC (Schnider et al., 2000) or reality monitoring (Nahum et al., 2012) is the only correlate of both the presence and clinical course of confabulation (Schnider et al. 2000; Schnider et al., 2013; Manuel et al., 2014). Temporal Context Confusion (TCC) is defined as the inability to filter out memories that do not belong to ongoing reality (Schnider 2003). Results from the current study partially replicated the work by Schnider and colleagues. 71% of the present confabulators scored above the cut-off point that would index confabulation according to Schnider and colleagues, and all healthy controls scored below this point. In this way the present results constitute a partial replication of Schnider's previous findings (Schnider et al., 1996).

However, contrary to Schnider's findings, seven confabulating participants scored below the critical cut-off point. In addition, the scores of the non-confabulating brain-injured patients were evenly distributed across both sides of the critical cut-off point (Fig. 1). This indicated that performance on the TCC task did not always discriminate between confabulating and non-confabulating memory-disordered patients. The non-confabulating brain injured participants' performance on this task was very similar to that of the non-confabulating anterior communicating artery aneurysm (ACoA) group reported by Gilboa et al. (2006). This may relate to the severity of executive dysfunction experienced by both our brain-injured and Gilboa et al.'s ACoA groups. Moreover, TCC did not differentiate significantly the confabulating and non-confabulating brain-injured groups; and it correlated only at a near-significant level ($p < 0.06$) with total confabulations on the Dalla Barba battery.

4.2.2. The role of insight and mood state in the onset of confabulation

Our measures of 'insight' and 'elated mood' did each differ significantly between the confabulating and non-confabulating brain-injured groups. Moreover, a ROC analysis, based on these two variables, predicted group membership (confabulating versus non-confabulating brain injury) with 78% sensitivity and 82% specificity.

The role of insight in the onset and clinical course of confabulation has not been formally studied previously. The present findings provided evidence that insight into memory difficulties and well-being might be an important factor in the appearance and clinical course of confabulation. These results are consistent with previous observations indicating that recovery from confabulation is accompanied by improved awareness of deficits (Mercer et al., 1977; Feinberg & Roane, 1997). Somewhat similarly, Schnider (2008) has argued that confabulation is caused by deficits in experiencing ongoing reality, and others have cited a disconnection from the external world (Feinberg & Roane, 1997), or a lack of integration in memory processes (Conway, Collins, Gathercole, & Anderson, 1996). Indeed, there is some evidence that clinical interventions, aimed at improving awareness and self-monitoring have improved confabulation in clinical patients, although the precise mechanism whereby this has happened is not clear (Dayus & Van den Broek, 2000; DeLuca, 2009). With respect to mood state, the present findings are consistent with previous observations that elated mood is associated with a liberal response bias on recognition memory tests, which has been reported to subside as the patient's mood returns to normal (Corwin, et al., 1990). Such findings are consistent with other evidence that affective factors may influence the onset and characteristics of confabulation in patients with weak memory or impaired monitoring mechanisms (Conway, 2005; Fotopoulou, 2010; Gilboa, 2010; Metcalf et al., 2010). In a previous study, our group found that confabulated memories contained a significantly higher proportion of affective content (both pleasant and unpleasant) than did 'true' memories (Bajo et al., 2010). It is conceivable that these affective factors might influence

strategic control, trace specification, or verification processes in memory retrieval (Burgess & Shallice, 1996; Moscovitch & Melo, 1997; Schacter et al., 1998; Gilboa et al., 2006).

4.2.3. Memory and executive function in the onset of confabulation

The main factors which correlated with the severity of the total and episodic confabulations across individual patients were impaired autobiographical memory (young adult and recent memories), verbal anterograde memory (immediate and delayed Logical Memory), and errors on executive tests (cognitive estimates, Hayling test). Taken together, a stepwise regression, based on AMI young adult and recent scores, as well as the TCC score, predicted 49% of the variance in terms of total confabulations. Previous studies have obtained variable findings with respect to the association between executive test performance and confabulation, some reporting strong associations (e.g. (Stuss et al., 1978; Kapur & Coughlan, 1980; DeLuca & Cicerone, 1991; DeLuca & Locker, 1996; Ghosh et al., 2014) and others reporting weak or no association (Gilboa, et al., 2006; Bouzerda-Wahlen et al., 2013). Johnson et al. (1997) suggested that a weak autobiographical memory was also a factor promoting confabulation on the basis of a single case but, to our knowledge, this has not been systematically demonstrated before.

4.3. Follow-up of confabulation

Very few previous studies have examined the clinical course of confabulation, and its correlates. Schnider et al. (2000; Nahum et al., 2010, 2012) found that temporal context confusions/reality disorientation did indeed decline in parallel with recovery from confabulation. Box, Laing & Kopelman (1999) showed that confabulation can occasionally evolve into other types of delusional disorder. Schnider (2008) reported that dopamine antagonists sometimes reduce

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confabulation. Corwin et al. (1990) found that beta-blockers reverse elated mood disorders, and can dampen an excessive willingness to guess during recognition memory tasks.

In the present investigation, we found that, across the entire group, TCC errors did indeed come down in parallel with the decline in confabulations, as Schnider et al. (2000) had previously demonstrated. On the other hand, there were no significant correlations between the decline in temporal context confusions (between T1 and T3) with either the total number or purely episodic confabulations on the Dalla Barba battery.

Likewise, our measure of the loss of insight also improved through time in parallel with recovery from confabulation; and there was some improvement in terms of elated mood, again in parallel with recovery from confabulation. However, neither of these measures (nor depressed mood) was significantly associated with either the decline in total confabulation or the decline in episodic confabulation scores.

What appeared to be significant correlates of the decline in confabulation were improvements in AMI episodic child and young adult memories, verbal anterograde memory (delayed Logical Memory scores) and, in particular, the decline in errors on the cognitive estimates test. This suggests the importance of memory performance (particularly autobiographical memory) and improvements in executive function in determining the outcome of confabulation. Stepwise regression based on change in cognitive estimates and change in AMI scores predicted 44% of the variance in terms of change in total confabulation scores. Again, this finding is consistent with the observations of some of the older literature, which placed emphasis on a combination of executive and memory dysfunction (Baddeley & Wilson, 1986; Kopelman, 1987; DeLuca & Cicerone, 1991). It highlights the inability to edit out errors, as demonstrated by Shallice and Evans (1978), and a weak autobiographical memory, as postulated by Johnson et al. (1997).

4.4. Strengths and limitations

The key strength of this study was the relatively large number of participants, compared with previous investigations, who are representative of brain injured patients seen in routine NHS practice. Another strength was that they were followed up for 9 months. The main limitation was the variation in stage of development of the different schedules we have used. The newest schedules such as the insight measure were likely to be subject to a greater degree of measurement error, which may have partly obscured any association with confabulation, and consequently comparisons between the schedules in the strength of their association with confabulation must be made with caution.

4.5. Summary and Conclusions

In summary, temporal context confusions (TCC) reality orientation was sensitive, but not specific, to confabulation. There was a weak correlation at baseline with the severity of total confabulations across patients, although this was not present for episodic confabulations, taken in isolation. Elation and low insight better predicted the presence of confabulation versus no confabulation in brain injury patients, although these did not correlate significantly with the severity of confabulation, and they could conceivably be a consequence (rather than the cause) of confabulation. Significant correlates of episodic and total confabulations were executive function (errors on the Hayling and cognitive estimates tests), poor anterograde memory (story recall), and weak autobiographical memory retrieval (on the AMI).

With respect to change through time, temporal context confusions, insight score and elation score, all improved in parallel with confabulation. However, these factors were not significantly

correlated with change in confabulation scores at 9-months' follow-up. From our correlational analyses, it would appear that weak memory (especially autobiographical memory) and executive function (as measured by cognitive estimate scores) were the strongest correlates of *both* the initial severity of confabulation *and* change in confabulation over 9 months.

More generally, elated mood and lack of insight may contribute to the occurrence of confabulation by creating excessive confidence and willingness to report false memories. Temporal context confusions/ impaired reality monitoring (at least as measured by the Schnider test) is often present in confabulation, and in general decline in parallel with recovery from confabulation, but these confusions are not specific to the presence of confabulation nor closely correlated with its severity. It appears that spontaneous confabulation is most likely to arise in the context of impaired autobiographical memory and executive function, particularly with respect to the monitoring/editing out of errors. This failure to edit out errors may also include the failure to reject inappropriate schema, as suggested by Ghosh et al. (2014).

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TABLES

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Table 1. Demographic and injury characteristics. *Mean (SD) of age, years of formal education, post traumatic amnesia (PTA), and post-injury interval of 3 groups: brain injured confabulating patients, brain injured amnesic non-confabulating patients and healthy controls.*

	N	Mean Age	Education (yrs)	Post-injury (months)	PTA (days)
Confabulating brain-injured	24*	51.5 (± 10.2)	12.1 (± 2.8)	6.1 (± 3.7)	30.4 (± 28.4)
Non-confabulating brain-injured	11	41.9 (± 13.3)	12.1 (± 2.8)	11.4 (± 11.6)	48.3 (± 41.4)
Healthy controls	6	51.2 (± 8.5)	13.5 (± 2.2)	-	-

*20 had acted on their confabulations. 21 had imaging available: 10=VMF/O-F pathology; 8 widespread atrophy; 3 no visible VMF/O-F change

Table 2. Background cognitive tests. *Mean raw scores and percentiles of 24 confabulating and 11 non-confabulating brain injured participants on background cognitive tests*

	Confabulating participants		Non-confabulating participants	
<i>Test</i>	<i>Mean (SD)</i> <i>raw score</i>	<i>percentile/</i> <i>classification</i>	<i>Mean (SD)</i> <i>raw score</i>	<i>percentile/</i> <i>classification</i>
<u>General reasoning</u>				
NART premorbid IQ	93.8 (15.85)	34	90.6 (7.75)	27
WASI current full scale IQ	77.7 (12.70)	7	76.1 (10.78)	5
<u>Speed of processing</u>				
SCOLP	22.8 (10.64)	1 st -5 th	27.3 (8.78)	1 st -5 th
WAIS-III - Digit Symbol	23.5 (13.82)	1 st	23.4 (13.91)	1 st
<u>Executive function</u>				
Trail Making Test – B	254.1 (115.6)	10 th	255.0 (130.9)	10 th
Cognitive Estimates Test	14.2 (5.5)	1 st	11.6 (5.7)	1 st
Hayling Test – Part A timing score	36.5 (22.6)	5 th	30.4 (28.5)	5 th
Hayling Test – Part B timing score	81.4 (47.5)	10 th	80.0 (43.0)	10 th
Hayling Test – Part C type a & b errors	40.7 (23.6)	1 st	30.6 (23.3)	1 st
Brixton Test	31.1 (10.8)	1 st	28.6 (11.1)	1 st
<u>Anterograde memory</u>				
WMS-III – Immediate Logical Memory	12.3 (8.2)	1 st	15.3 (6.8)	1 st
WMS-III – Delayed Logical Memory	3.1 (4.3)	1 st	4.6 (4.7)	1 st
WMS-III – Recognition Logical Memory	18.6 (3.6)	-	20.5 (2.2)	-
WMS-III - Immediate Visual Reproduction	41.0 (16.7)	1 st	49.1 (27.5)	1 st
WMS-III - Delayed Visual Reproduction	6.8 (8.9)	2 nd	11.5 (13.6)	2 nd
WMS-III - Recognition Visual Reproduction	34.6 (4.0)	5 th	34.7 (7.8)	5 th
<u>Autobiographical Memory</u>				
AMI – episodic – childhood	5.0 (0.5)	Borderline	6.0 (0.7)	Acceptable
AMI – episodic – young adulthood	4.9 (0.4)	Borderline	6.4 (0.7)	Borderline
AMI – episodic – recent events	3.0 (0.5)	Abnormal	5.4 (1.0)	Abnormal

Table 3. Experimental tasks. Means and standard deviations of scores obtained by each group of participants on experimental measures, and significance of differences between confabulating and non-confabulating participants (TCC: Temporal Context Confusion)

	Confabulating participants	Non-confabulating participants	Healthy participants	Prediction of confabulation in Confabulating vs Non-confabulating participants
<i>Test</i>	<i>Mean (SD)</i>	<i>Mean (SD)</i>	<i>Mean (SD)</i>	
TCC	0.5 (0.4)	0.3 (0.4)	0.1 (0.1)	P=0.21
Insight	8.3 (3.4)	5.6 (2.5)	-	P=0.03
Elated mood	4.0 (3.3)	1.7 (2.3)	3.2 (3.9)	P=0.04
Depression	3.4 (2.8)	3.5 (3.2)	3.5 (3.5)	P=0.99

Table 4. Correlates of severity in confabulation (within the confabulating group). *Size and significance of correlations between neuropsychological tests and number of confabulatory answers to the Dalla Barba confabulation interview (1. overall and 2. episodic section) at the first assessment.* (TCC: Temporal Context Confusion; AMI: Autobiographical Memory Interview)

	Total Confabulations T1	Episodic Confabulations T1
Schnider's TCC score	0.34 ($P=0.05$)	0.01 ($P=0.48$)
AMI episodic adult	- 0.45 ($P=0.02$)	-0.42 ($P=0.02$)
AMI episodic recent	- 0.48 ($P=0.01$)	-0.49 ($P=0.01$)
Immediate Logical Memory	- 0.41 ($P=0.03$)	-0.35 ($P=0.06$)
Delayed Logical Memory	- 0.29 ($P=0.10$)	-0.40 ($P=0.03$)
Cognitive Estimates errors	0.43 ($P=0.02$)	0.37 ($P=0.04$)
Hayling errors	0.49 ($P=0.01$)	0.50 ($P=0.01$)

Table 5A&B. Correlates of *decline* in confabulation across 24 confabulating individuals on A. Experimental measures and B. Background cognitive measures.

5A. Experimental measures. *Correlation values between change in experimental measures and change in episodic/overall confabulatory answers (change in this case is measured by subtracting final assessment scores from initial scores)*

	Total Confabulations T1 – T3	Episodic Confabulations T1 – T3
Temporal Context Confusion T1-T3	0.05 (P=0.41)	0.02 (P=0.46)
Elated Mood T1-T3	-0.10 (P=0.32)	-0.07 (P=0.38)
Depressed mood T1-T3	-0.26 (P=0.12)	0.25 (P=0.13)
Insight	0.10 (P=0.33)	0.09 (P=0.34)

5B. Background cognitive measures. *Size and significance of correlations between change in neuropsychology measures and change in episodic / overall confabulatory answers (change in this case is measured by subtracting scores final assessment from initial scores)(AMI: Autobiographical Memory Interview; T1: baseline; T3: final assessment)*

	Total Confabulations T1 – T3	Episodic Confabulations T1 – T3
AMI episodic child T1-T3	- 0.43 (P=0.035)	-0.06 (P=0.40)
AMI episodic adult T1-T3	- 0.63 (P=0.00)	-0.31 (P=0.09)
Delayed Logical Memory T1-T3	-0.26 (P=0.13)	-0.40 (P=0.03)
Cognitive Estimates errors T1-T3	0.46 (P=0.02)	0.51 (P=0.01)

FIGURES

Captions for Figures

Figure 1. Temporal Context Confusion (TCC). Scatter distributions of TCC scores for 24 confabulating patients, 11 non-confabulating brain injured amnesic patients, and 6 healthy controls. $TCC = (FP2/hits2) - (FP1/hits1)$. The horizontal line shows the cut-off point reported for healthy controls (0.28) by Schnider et al. (1996)

Figure 2. Receiver Operating Characteristics curve of fitted values of insight and elated mood at initial assessment (the dashed line represents the fitted values of the joint variable (insight & elated mood) and the single diagonal line represents chance performance)

Figure 3A&B. Confabulation and experimental measures over time.

3A. Clinical course of confabulation and Temporal Context Confusion (TCC) over time. 1. Left vertical axis: Mean proportion of confabulatory answers reported on the Dalla Barba interview a) across all sections, or b) on the episodic section alone; and 2. Right vertical axis: Mean TCC scores of 24 confabulating participants at 3 assessment times. Lower scores indicate better TCC performance

3B. Episodic confabulations, insight, elation and depressed mood over time. Left vertical axis: raw number of confabulatory responses to the Dalla Barba episodic section over time. Right vertical axis: Raw scores obtained by the confabulating group over time on a) insight, b) elation, and c) depression questionnaires. Decreasing scores indicate better functioning.

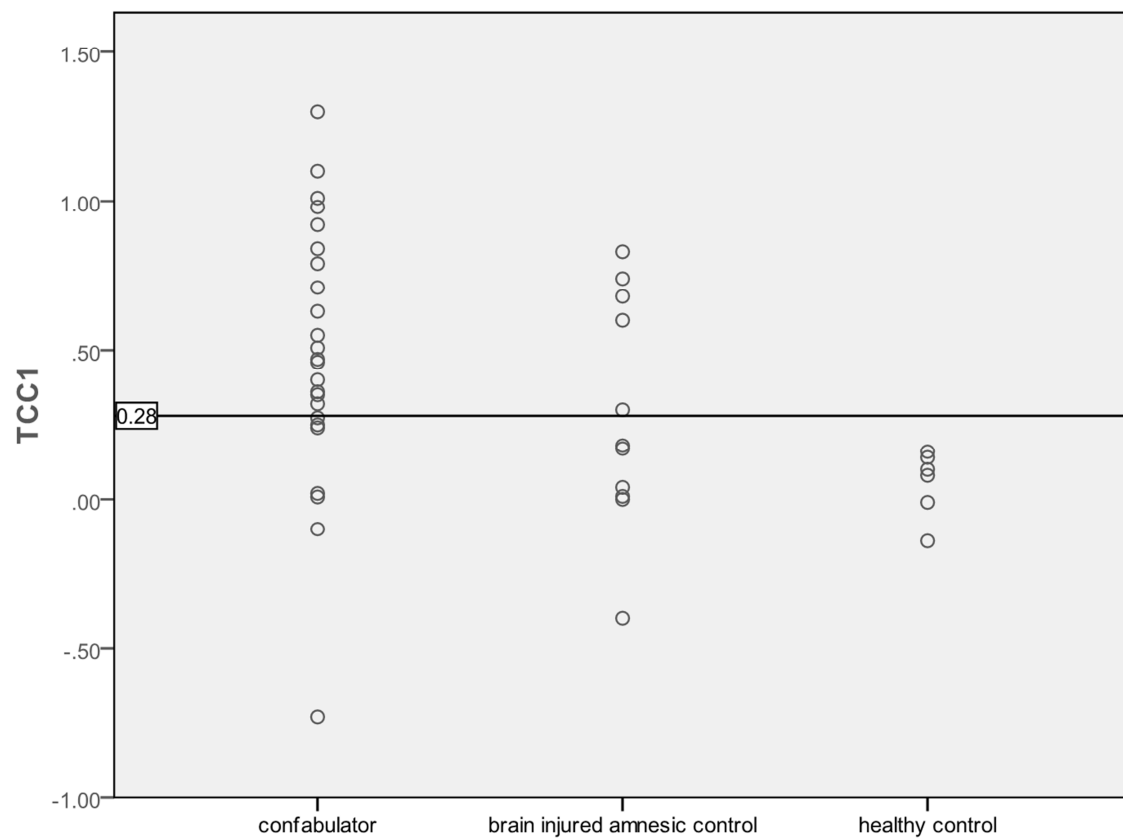
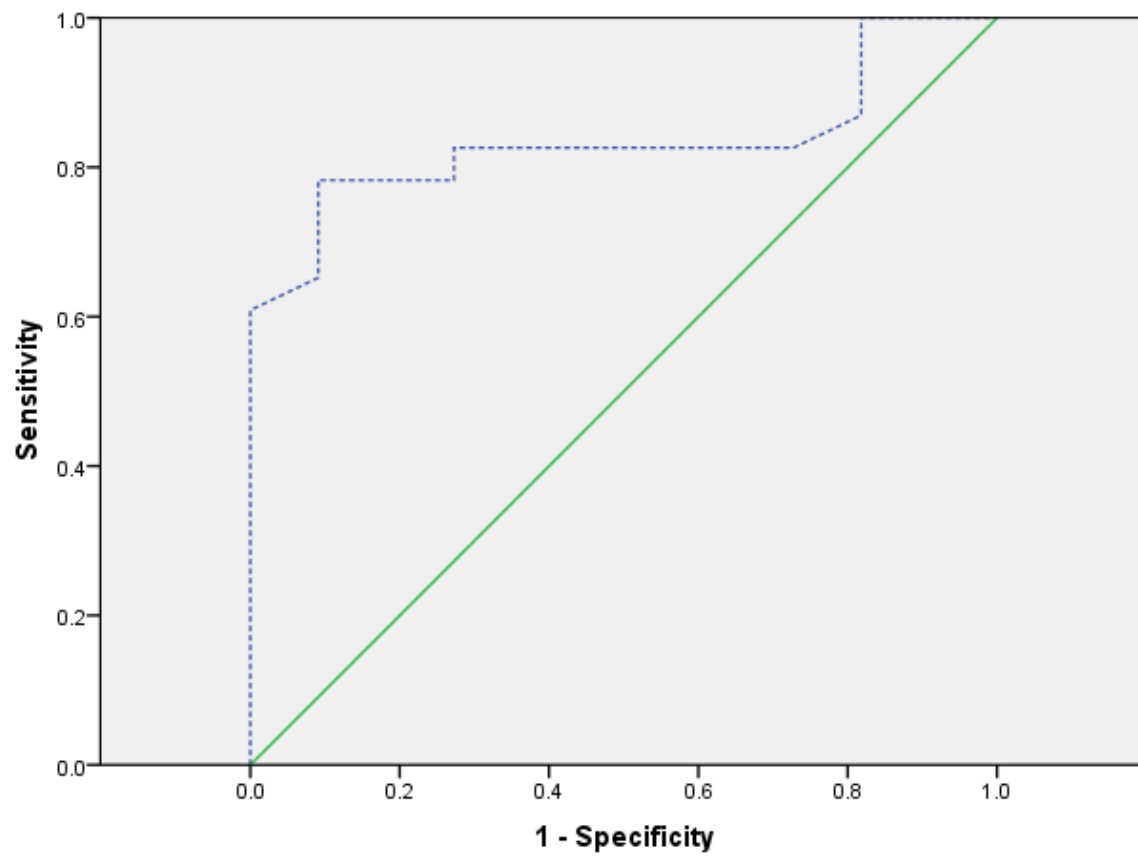
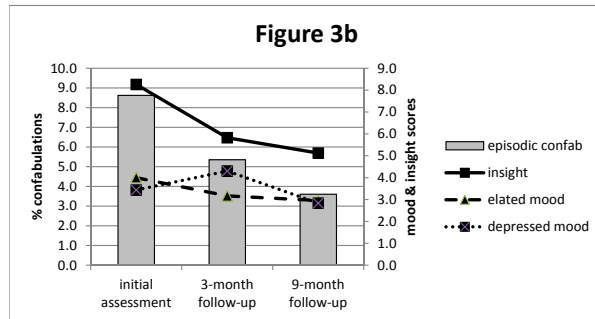
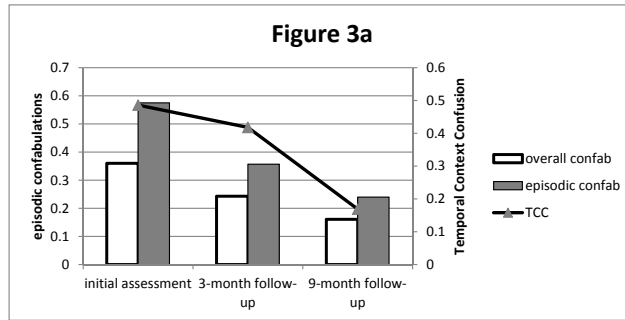
Figure 1.

Figure 2.

Diagonal segments are produced by ties.



	Critical slide	Non-critical slides
initial assessment	0.348	0.345
3-month follow-up	0.475	0.36
9-month follow-up	0.603	0.399

overall con episodic cc TCC

initial asse:	0.36	0.575	0.486
3-month fo	0.243	0.357	0.418
9-month fo	0.161	0.24	0.169